Building Information Modeling (BIM) in Morocco: Awareness, Implementation and Adoption Measures

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***Abstract*— Considering the proven advantages of Building Information Modeling (BIM) for saving time and cost, and enhancing quality and decision making, BIM adoption is getting an upward worldwide spread, especially after COVID19 emergence. Several recent studies have proven that BIM could considerably help to overcome the heavy impacts of the pandemic. However, its adoption remains a challenge for developing countries such as Morocco, where no record about BIM awareness or implementation has been published. This paper aims to fill this gap by using embedded methodological design including literature review, web-based and interview-based surveys, interviews, documents' scan and archival data. This paper revealed that the awareness level of the BIM concept and BIM tools are 77% and 73% respectively whereas the actual understanding of them is still limited to 51%. This study disclosed that, despite BIM is already adopted in some big projects in Morocco, its implementation remains limited to 24%-rate with varying levels depending on the stage of AEC projects lifecycle. Furthermore, this paper illustrates the repartition of Moroccan AEC stakeholders according to each utilized parameter of BIM maturity and highlights the existing measures urging BIM adoption.**

***Index Terms*— Construction, Developing Countries, Building Information Modeling (BIM), BIM Maturity, Africa**

I. Introduction

The Architecture, Engineering, and Construction (AEC) industry is an important economic sector in Morocco. It is the third jobs generator with almost one million permanent jobs and up to 75,000 temporary jobs created annually [1]. More than 7,500 companies, of all sizes, are directly operating in this industry and it contributes by almost 7% of the Moroccan Gross Domestic Product (GDP) [2]. However, beside the common worldwide AEC challenges, FNBTP et al. [3] highlighted that the national AEC industry struggles with considerable challenges related to the local business culture and bureaucracy which cause further delays and limit the related profitability and efficiency. Namely, lack of efficient management procedures, lack of decision-making tools, lack of efficient information management and the culture of awarding contracts based on the lowest prices.

The annual reports of Bank El Maghreb [4] showed that the Moroccan AEC industry is mostly based on public investment with an average of 73% through two main approaches: direct investments and financial incentives. In terms of direct investment, Morocco mainly invests in infrastructure facilities to meet two of the national strategic goals: facilitate transportation and connection between the twelve regions of Morocco and enhance the Moroccan capacity to be an economic hub in Africa.

In this purpose, many programs have been launched, namely transportation facilities (highways, roads, sanitation network, bridges…) [5], industrial platforms (Sapino, MCA industrial zones, Atlantic free zone P2I…) [6], [7], [8], economic hubs (Technopolis, Oujda Nearshore, Casa-Anfa Zone of Casa Finance City) [9], [10] and trading-logistic platforms (Tanger Med, Nador west Med, Laayoune port…) [11], [12], [13]. In 2004, the 'Agence Nationale de lutte contre l'Habitat Insalubre' (ANHI) merged with other public real-estate companies to create "El Omrane" that leads the servicing work and master planning of new neighborhoods and cities in Morocco [14]. In terms of financial incentives, Morocco encourages real-estate developers to invest in affordable and social housing by either offering them fields at low prices, compensating a part of their investment, exonerating them from sizable taxes [15], or giving them special derogations [16].

The AEC industry was one of the most affected economic sectors by COVID19 impacts [17]. Indeed, because of the imposed restrictive measures, mainly social distancing and

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travel bans, the construction activities were considerably disturbed in terms of supply chain and worksites activities. In April 2020, 95% of architectural and engineering firms and developers and 90% of suppliers and contractors stopped their activities [18]. By the end of 2020, the AEC companies registered -32% of their revenue, -44% of operating income and -76% of net income [19] leading, thereby, to a 1.6%-drop in the national 2020-GDP [20]. Likewise, the construction activities experienced a noticeable decline in 2020 compared to 2019, with -49% of new construction authorizations, -38% of built fields' area and -34% of built dwellings [21] (Fig. 1).

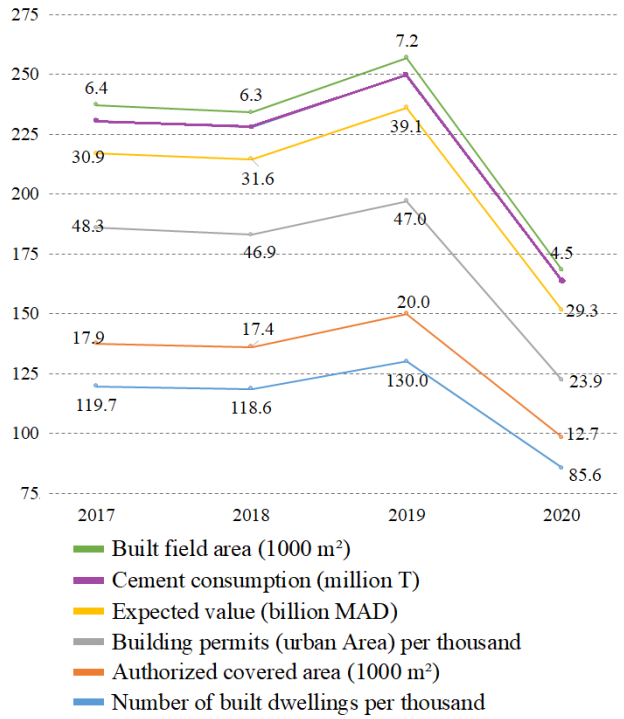

Fig. 1 Variation of construction indexes in Morocco, data collected from [21]

Several studies [22], [23] proved that construction Information, Communication, and Technologies (ICTs), namely Building Information Modeling (BIM), could help to overcome the heavy impacts of COVID19 pandemic on the AEC industry. Indeed, COVID19 circumstances highlighted the BIM ability to allow working remotely and relatively keep the construction workflow in challenging conditions [24]. BIM becomes increasingly important in terms of innovation [25], and creation of new tools to design, manage, and erect [26] construction projects. Due to COVID19 impacts, the BIM market reached $5.2 billion in 2020 and is expected to increase to $10.7 billion by 2026 [27]. Despite the increasing adoption rate of BIM worldwide, its adoption is still in the primary stage in Africa [28].

Morocco is one of the African countries that are engaging steady strategies to structure and enhance the AEC-related fields, particularly after the heavy impacts of COVID19 on the Moroccan AEC industry [19]. As noticed in leading countries in BIM implementation, BIM could be a revolutionary practice for the AEC industry in Morocco. However, the literature review reveals an absence of papers and documents discussing the actual state-of-the-art of BIM adoption in this country.

This study aims mainly to fill this knowledge gap and pave the path for researchers and decision-makers to develop founded BIM studies and strategies in this region. It addresses the following objectives: (1) Evaluate the awareness of both BIM concept and BIM tools; (2) Assess the different aspects of BIM implementation (Extent of BIM adoption by stage, adopted and planned BIM adoption strategies, Used tools, Used BIM maturity for deliveries, and Level of green BIM adoption), and (3) Highlight existing measures for BIM adoption. For this purpose, this paper is structured as follows: First, it provides an intent literature review, then explains the adopted research methodology, lays out the main findings, and gives a thoughtful discussion. In the end, it presents the conclusions and research limitations.

II. LIETRATURE REVIEW

BIM is an emerging technology that proved significant operational, ecological, and financial potential in the AEC industry. However, the extent of this potential strongly depends on the chosen BIM tools, namely software, hardware and collaboration platform, and BIM model maturity which is defined by 3 parameters: Level of collaboration, commonly named Level (L), Level of development (LOD) and Dimension (D). Eadie et al. [29] presented 4 LOC, where L0 means that the project stakeholders work on fully independent plans and L3 means that they collaborate on a sole integrated BIM (iBIM) model, L0 is not considered as a BIM level.

In a previous study, Bouhmoud and Loudyi [30] identified 5 LOD that define the degree of detail of the model components going from sketch for LOD100 to as-built for LOD500. Meanwhile, D represents BIM models' scalability as 3D (volume) models could be upscaled to higher Ds according to included properties. Most known Ds are 4D, 5D and 6D that refer to 3D+cost, 3D+time and 3D+ environmental sustainability, respectively [31]. Lately, Ds were extended to include the facility management, safety, lean construction management and industrialization through 7D, 8D, 9D and 10D, respectively [32]. Ultimately, a BIM model could be synthetized into the following equation (adapted based on [30]):

$$\text{BIM Model} = \text{Model}(x.D, y.LOD, z.L), \text{ Where:}$$
$$x \in \{3, 4, 5, 6, 7, 8, 9, 10, X\}$$
$$y \in \{100, 200, 300, 350, 400, 500\}$$
$$z \in \{1, 2, 3\}$$

Several studies have presented BIM awareness and/or implementation in different regions. Charef [33] pointed out that UK, Sweden, Denmark, Finland, Estonia, and the Netherlands have the highest BIM adoption rates in the European Union (EU). Since 2017, the EU countries are strengthening their BIM adoption policies through different measures, namely mandatory BIM standards and guidelines [34]. Jones and Jones and Laquidara-Carr [35] confirmed that the average rate of BIM adoption in the transportation and infrastructure sectors improved from 25% in 2017 to 65% in 2019 in the UK, France, and Germany. In the USA, BIM adoption took a fast track and exceeded 70% in 2016

[36] upheld by a remarkable policymakers buy-in. In China, Jin et al. [37] stated that Chinese AEC operators are largely aware of BIM with at least 63% of them are using it at a moderate level.

In India, Jagadeesh and Jagadisan [38] pointed out that BIM awareness reached 66% in 2019 but the implementation rate is still limited to 21%. In Chile, Bnamericas [39] stated that BIM software was used by 69% of the AEC firms in 2019 against 53% in 2016, and the core group of firms that use BIM software as a standard procedure grew from 22% in 2016 to 34% in 2019. Whereas Saka and Chan (2019) highlighted that BIM adoption is still very low in Africa, even though the surveyed BIM awareness rates in Egypt, Nigeria, Kenya, South Africa, Ghana, and Libya are respectively 93%, 89.39%, 88.7%, 70%, 58.6%, and 45.33%.

Bui et al. [36] mentioned that developing countries' firms view BIM as a complex working tool and risky investment as its business value is unclear. Al-Ashmori et al. [40] confirmed that, in Malaysia, BIM awareness level is limited to 45% of local AEC stakeholders. Similarly, in Jordan, Matarneh and Hamed [41] revealed that only 5% of the AEC stakeholders are using BIM and only large organizations have prompted a move towards its adoption. Similarly, Rodriguez et al, [42] showed that the BIM awareness rate in the Philippines is close to 76% among the AEC stakeholders and 34% of them are BIM software users. Likewise, Gamil [43] explained that BIM awareness rate in Yemen is confined to 62% and BIM adoption is limited to 8.2%.

Moreover, Cheng and Lu [34] traced the worldwide developed BIM standards/guidelines regulating BIM implementation where a total of 123 BIM standards/guidelines were chronologically listed, 44.7% of them were developed by public bodies. The USA topped the list with 47 identified BIM standards/guidelines, followed by Asia (Singapore, South Korea, Japan, China, Hong Kong, and Taiwan), Europe (UK, Norway, Denmark, Finland, Netherlands, and Sweden) then Australia with respectively 35, 34 and 15 ones. Similarly, McAuley et al. [44] identified the undertaken measures by worldwide governments toward BIM implementation where they showed that several countries in the Americas (Canada, USA, Brazil, and Chile), Europe (UK, Norway, Finland, France, Germany, Italy, Spain, and the Netherlands), Asia (China, Hong Kong, Singapore, UAE, and Malaysia), and Oceania (Australia and New Zealand) either mandated or are planning to mandate BIM in at least public construction projects. However, no undertaken measure toward BIM implementation was identified in Africa, which confirms the findings of the studies [28], [45] revealing that BIM is still in the infant stage in this continent.

III. METHODOLOGY

To meet the objectives of this research, a six-step embedded research design is developed as follows: 1) Questionnaire design, 2) Identification of the targeted respondents, 3) Web-based and interview-based surveys, 4) Findings and validation of the new ones, and 5) Discussion and conclusion (Fig. 2).

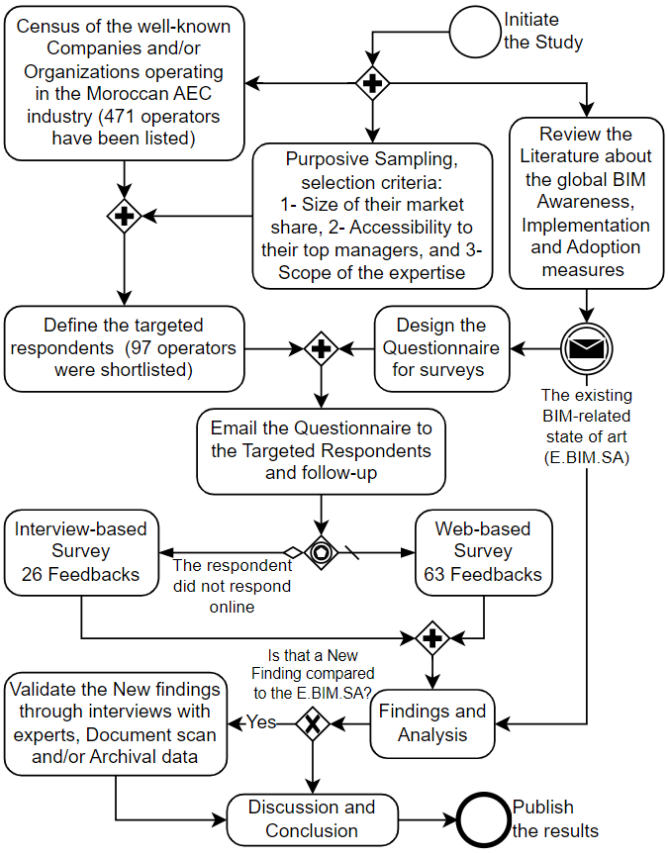

Fig. 2 Methodology workflow

A. *Questionnaire Design*

Based on the literature review and analysis of the Moroccan AEC industry context a 25-question questionnaire was designed in collaboration with a sociologist that reformulated the questions according to the category of targeted respondents. The questionnaire combined open-ended questions, close-ended questions, and open questions. The respondents had the possibility to suggest any possible missing point on some of the proposed lists.

B. *Identification of the Target Respondents:*

To have pertinent feedbacks reflecting the factual BIM situation and perspectives in Morocco, the authors used a purposive sampling technique [46], an initial listing of 471 companies/organizations operating in the different disciplines of AEC industry was obtained. The listing was based on the official data given by the following organizations: Moroccan's National Order of architects [47], Moroccan ministry of equipment, transport, logistics and water [48], [49], Stock Exchange of Casablanca [50] and the Moroccan Office of Industrial and Commercial Property [51]. Among those, 97 large-scale companies/organizations were selected based on three criteria: (i) The accessibility to their top management, (ii) The extent of their work scope, and (iii) The size of their market shares.

Particularly, two administrators, namely "Ministry of Equipment, Transport, Logistics, and Water" and "Ministry of National Territory Use Planning, Town Planning, Housing and City Policy", were chosen as they are the only organizations responsible for the development of AEC field in Morocco and for companies' accreditation in all categories of AEC industry. Two utilities' suppliers out of six existing

in Morocco were also shortlisted. Meantime, for education and R&D field, the authors were attentive to choose those covering most AEC expertise areas, namely:

- University Hassan II of Casablanca, which is the biggest university in Morocco,
- Hassania College of Public Works (EHTP) and Mohammedia College of Engineers (EMI), two oldest and most known schools for civil, mechanical, electrical, and plumbing engineering in Morocco.
- Office for vocational training and work promotion (OFPPT), the public organization in charge of promoting vocational training.

The selected targeted respondents included administrators (4.1%), Developers/Investors (21.6%), Architects (14.4%), Engineering firms (26.8%), Contractors/Suppliers (28.9%) and Education/AEC R&D (4.1%) detailed as following:

TABLE I. REPARTITION OF THE TARGETED RESPONDENTS BY DISCIPLINARY CATEGORIES

Category	Specialization	Nbr	Rate
Administrators (4.1%)	Ministry of Equipment, Transport, Logistics and Water (In charge of all aspects of Moroccan AEC industry)	1	1.0%
	Ministry of National Territory Use Planning, Town Planning, Housing and City Planning	1	1.0%
	Utilities' suppliers	2	2.1%
Developers / Investors (21.7%)	Real estate developers	12	12.4%
	Industrial/Tertiary developers	9	9.3%
Developers / Investors (21.7%)	Urban planners / Architects	11	11.3%
	Interior Architects	3	3.1%
Contractors / Suppliers (28.9%)	General contractors	17	17.5%
	Structural and MEP contractors	5	5.2%
	Finishes fields (carpenters, Painters, Coaters…)	4	4.1%
	AEC Software, Middleware and Hardware suppliers	2	2.1%
Engineering firms (26.9%)	Topography firms	5	5.2%
	Only Infrastructure and facilities studies	5	5.2%
	Multi-disciplined engineering firms	14	14.4%
	Consultancy -Training Firms	2	2.1%
Education / AEC R&D (4.1%)	Universities (Public)	1	1.0%
	AEC engineering colleges	2	2.1%
	Office for vocational training and work promotion (Public)	1	1.0%

C. *Web-Based and Interview-Based Surveys:*

To collect the feedback, a web-based survey was first conducted by sending the questionnaire by email to the targeted respondents, where 63 out of 97 replied. Then, an interview-based survey, by phone or in person, was conducted for the remaining 34 companies, where the interviewer was reading the questions and recording the answers on the questionnaire [52], and thus 26 feedbacks were collected.

D. *Validation of New Findings:*

The questionnaire serves either to confirm the existing findings or to identify new findings. Therefore, the authors conducted new data collection through new methods to verify and validate the accuracy and reliability of the new findings. In fact, they conducted interviews with experts and proceeded to document scan and archival data based on the confirmed data and statistics published online by reliable organizations or archived on their shelves.

IV. FINDINGS AND ANALYSIS

The surveys, both web-based and interview-based, led to collecting 89 feedbacks out of 97 giving a total response rate of 91.8%, which represents a very high response rate. The surveys were conducted in French, the business language in Morocco. Then, the answers to open questions were translated to English and verified by experienced engineers having large experience in running construction projects in English-speaking countries.

A. *Respondents' Background:*

To confirm the capacity of the respondents to give consistent feedback, two types of questions have been asked about the respondents' background. The first type was related to academic and professional background and the second type was related to the companies/organizations background they represent.

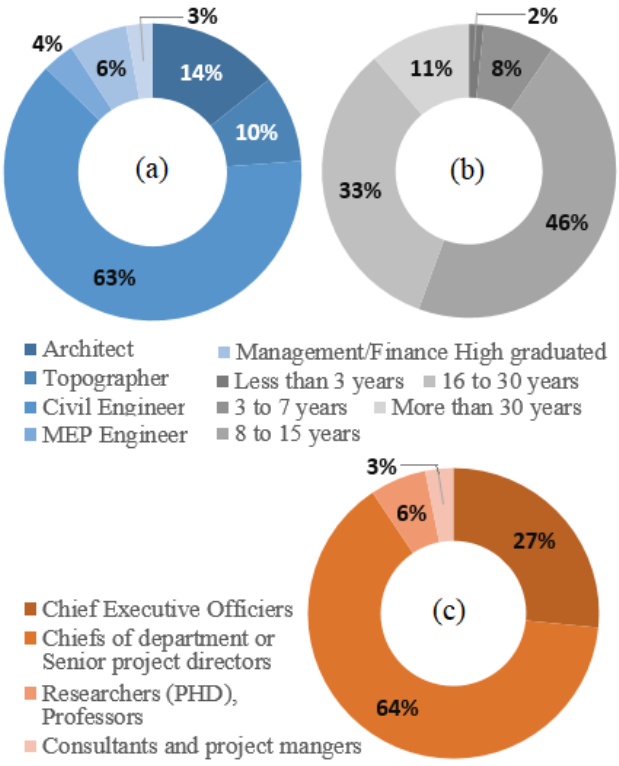

Fig. 3 Respondents' Background: (a) Academic background, (b) Experience and (c) Job positions

The respondents were mostly civil engineers followed by architects then topographers, and highly graduated from management or finance disciplines with rates of 63.5%, 14.3%, 9.5%, and 6.3% respectively (Fig. 3a). Besides, they had large experience in the AEC fields with a predominance of those having 8 to 15-year experience with 46% and 16 to 30-year experience with 33% (Fig. 3b).

The respondents generally had C-Level positions [53]

with 42.9% in C-Level positions related to Design and Development stage (chief of coordination department, chief of design department, chief responsible for development department…), 27.0% Direction positions (CEOs), 20.6% C-Level positions related to Erection and worksite stage (chief responsible for risk division, financial department or site management division…) and 9.7% of Researchers/Professors and M-Level (including 2 BIM Consultant/Coordinator) (Fig. 3c).

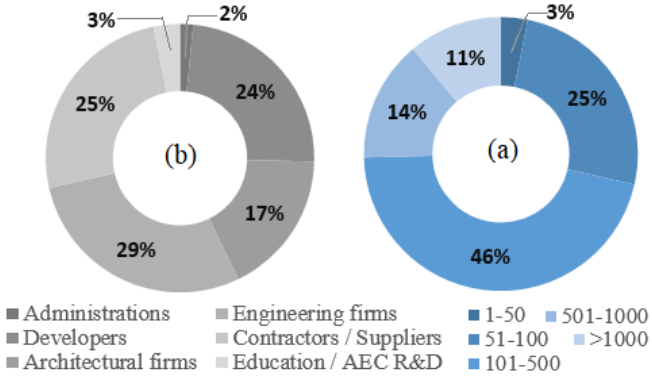

Fig. 4 Companies /Organizations background: (a) Discipline and (b) Number of employees

The responding companies/organizations were scaled according to both the number of their employees and the countries they are working in. In fact, the surveys confirmed that almost half (46.0%) of them are 101-500 employees' companies/organizations, the other half is divided as follows: 25.4% have 51-100 employees, 14.3% have 501-1000 employees and 11.1% have more than 1000 employees (Fig. 4a). Eight companies had not given their feedback: 3 Developers/Investors, 3 Architecture firms, 1 Topography firm, and 1 Contractor. Among the 89 responding companies /organizations, 29% were engineering firms, 25% contractors, 24% developers, 17% architecture firms, and 5% administrative and education/R&D organizations (Fig. 4b).

B. BIM Awareness:

1) Extent of BIM awareness and understanding:

In Best practices in sociology for measuring the degree of understanding of any concept is to ask the respondents to define and/or explain the concept. Then, submit the collected answers to the rating of experts who should give a score for each answer using a scale of 1 (Not aware) to 10 (excellent understanding) with 0 for invalid answers.

By using this method, the study pointed out that 77% of AEC stakeholders are aware of BIM concept with 51% having a correct to excellent understanding of BIM. Moreover, the mean of the definitions' scores is 4.2/10 illustrating a medium understanding of the effective meaning of BIM in Morocco. In fact, the given definitions show that at least 39% of AEC stakeholders are still confusing BIM with 3D digital model or limiting BIM to any AEC software developing 3D models.

2) Awareness of BIM tools:

The assessment of the AEC stakeholders' awareness of the BIM tools (Fig. 7) shows that BIM software is the most known BIM tool with 73% whereas only 11.1% have an idea about some collaboration platforms and barely 3.2% know about BIM hardware. Autodesk Revit is the most known BIM tool with 63.5% as rate of awareness, tailed by Autodesk Navisworks, BIM360, ArchiCAD, and Tekla with respectively 19%, 17.5%, 14.3%, and 7.9% share whereas the other software programs are limited to 3.2%. On the other hand, other than scanners, all known BIM hardware and collaboration platforms do not exceed 1.6% (Fig. 8).

Specifically, the study revealed that despite the spread of "Robot Structural Analysis" (RSA) use in Moroccan engineering firms, only 3.2% considered it as BIM software. Therefore, a new inquiry has been conducted among some respondents representing engineering firms. As result, the inquiry showed that RSA was not considered BIM software because it does not support IFC extension, which was the case for version 2.0 and earlier [54].

C. BIM Implementation Aspects:

To investigate BIM implementation aspects in Morocco, 12 questions among the 25 were designed to cover its related areas as follows:

TABLE II. QUESTIONS RELATED TO BIM IMPLEMENTATION

Sub-area	Question	Rank Value
Extent of BIM adoption	Do you use BIM in design/development stage?	Never/ 1-25%/ 26-50%/ 51-75% / More than 75%
	Do you use BIM in Erection/Construction stage?	Never/ 1-25%/ 26-50%/ 51-75% / More than 75%
	Would you, please, cite any company, organization or project that use BIM as main working tool?	Open question
Strategies toward BIM adoption	Has your firm set any strategy to adopt BIM as a working tool?	Yes, already done. Yes, it is in progress. No, but for very soon. No, we have not.
	What kind of actions your firm has already undertaken to adopt BIM?	Staff training BIM software acquisition BIM hardware acquisition Other:
Strategies toward BIM adoption	Has your firm set any strategy to adopt BIM as a working tool?	Yes, already done. Yes, it is in progress. No, but for very soon. No, we have not.
	What kind of actions your firm has already undertaken to adopt BIM?	Staff training BIM software acquisition BIM hardware acquisition Other:
Strategies toward BIM adoption	What are BIM tools you know?	Open question
	Among them, what the BIM tools you or your firms already use?	I use them all. I use none of them. Other:
BIM Delivery maturity	What LOD do you use for documents you deliver (design stage) or use (erection stage)?	LOD100/ LOD200/ LOD300/ LOD400/ LOD500/ I don't know
	What LOC do you use for documents you deliver (design stage) or use (erection stage)?	LOC0/ LOC0/ LOC2/ LOC3/ I don't know
	What dimension (D) do you use for documents you deliver (design stage) or use (erection stage)?	D2/ D3/ D4/ D5/ D6 or more/ I don't know
Existing measures urging BIM adoption in Morocco	Are there any existing measures (public incentives, laws or standards) using AEC stakeholders to adopt BIM as a working tool in Morocco?	Yes, there are some/many. No, there are none. I don't know.
	If yes, would you cite the existing public incentives?	Open question
	If yes, would you cite the existing laws or standards?	Open question

1) Extent of BIM Adoption by Building Stage:

BIM could be used in the different stages of the AEC project lifecycle: Design/development, erection/ construction, and maintenance/ exploitation. However, since we are interested only in the building process, we limited this research to mainly the two first stages Design/Development, and Erection/ Construction.

This study pointed out that many projects, in Morocco, already use BIM as a main working tool such as the Casa-Finance-City tower, Big Theater of Rabat, Popular Bank tower, Medical Center of Sheikh Khalifa, and Royal Mansour Hotel.

However, BIM adoption is still very limited especially in the Erection/Construction stage. In fact, almost 62% of the AEC stakeholders still do not use BIM in any of their projects, 25.4% barely used it with a percentage scrolling between 1 and 25% of the projects they were undertaking and only 0.2% implemented BIM in more than 75% of their projects (Fig. 5). Likewise, in the Design/Development stage, 55.6% of AEC stakeholders have never used BIM and only 6.3% of the AEC stakeholders used BIM in more than half of their projects with a very tight rate (0.2%) of those that used it in more than 75% of their projects (Fig. 5).

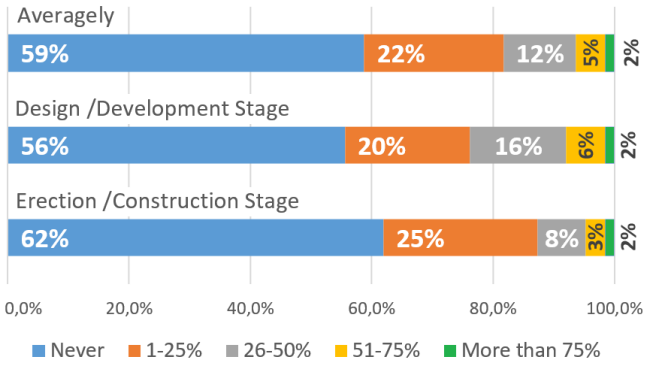

Fig. 5 Breakdown of AEC stakeholders according to the rate of using BIM in their projects

2) Adopted or planned strategies for BIM implementation:

The study about the adopted or planned strategies by the companies toward BIM adoption, if there are any, revealed that most of the AEC stakeholders (56%) do not have any strategy, with only 3% that are planning to prepare a strategy (Fig. 6). 44% of the respondents have already designed their strategies and undertaken at least one task toward BIM adoption, such as staff training and BIM software or hardware acquisition. Within them, 6% have already set their strategies and started extending the related implementation to all their projects and even convincing their clients to align with it. Likewise, the study showed that 33% of the AEC universities have equipped their laboratories with some BIM software and hardware for educational and R&D purposes (Fig. 6).

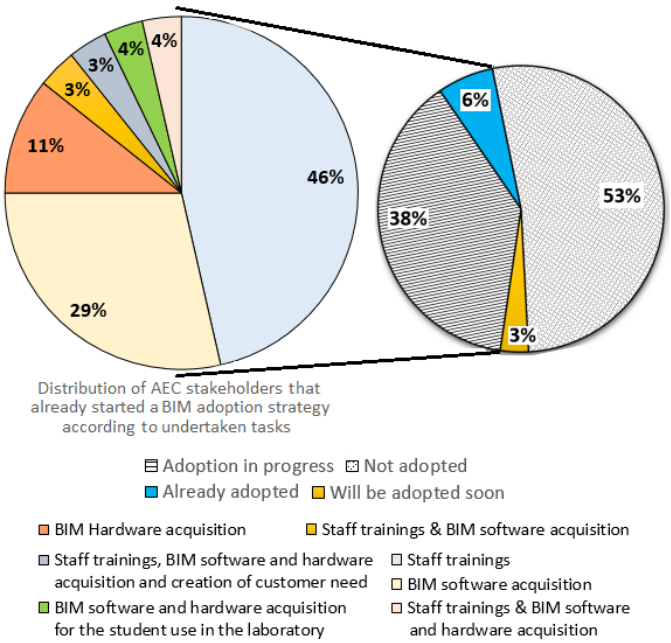

Fig. 6 BIM Adoption in Moroccan AEC industry and Breakdown of the 44% operators who have already started a strategy toward BIM Adoption per undertaken actions.

3) Used BIM tools:

One of the most important parameters to assess the degree of BIM implementation is "the weight of BIM tools' use". As a result, the study demonstrated that almost 62% of Moroccan AEC stakeholders have never used any BIM tools. In fact, in coherence with BIM tools awareness rates (see § BIM Awareness), BIM software is still the most used BIM tool followed by BIM hardware with 6.3% and only 1.6% for BIM collaboration platforms use (Fig. 7 and 8).

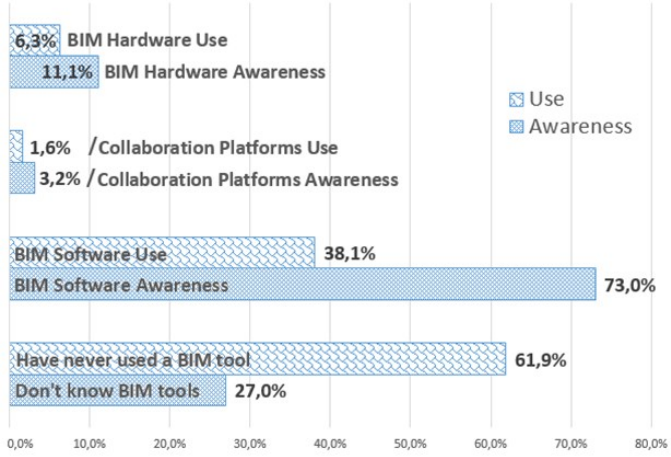

Fig. 7 Overall Repartition of AEC stakeholders according to Awareness and Use of BIM tools by type

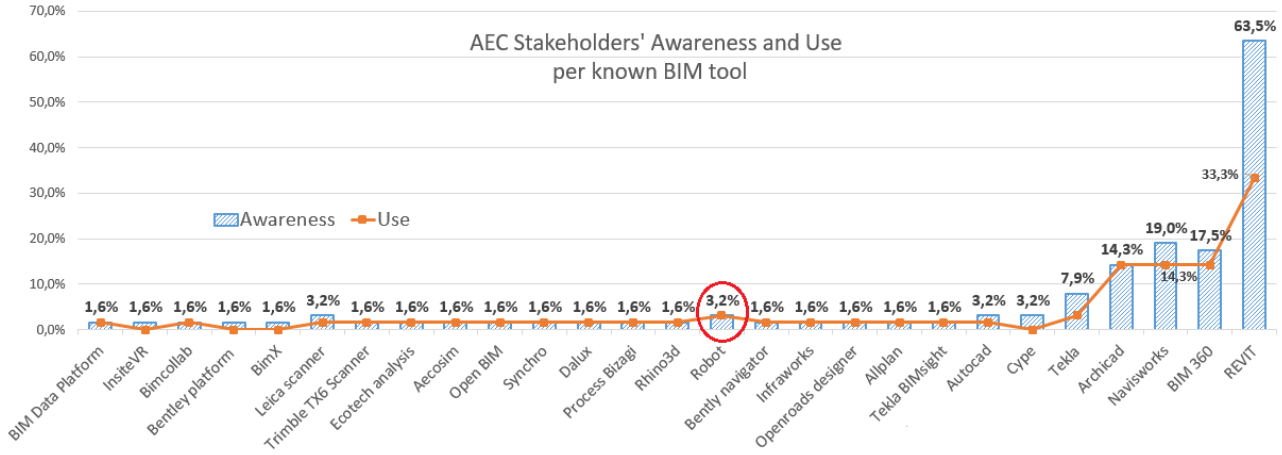

Fig. 8 Repartition of AEC stakeholders according to Awareness and Use of BIM tools

D. BIM deliveries Maturity:

Studying the adopted parameters for BIM deliveries brings out the real implementation level of BIM in its different aspects such as level of collaboration and level of information development. Afresh, this study revealed that more than half of Moroccan AEC stakeholders still do not have a clear idea about BIM and their benefits or do not use it in their projects and use the traditional practices. Likewise, it showed that the delivered BIM models in Morocco have a low or medium BIM maturity (Fig. 9).

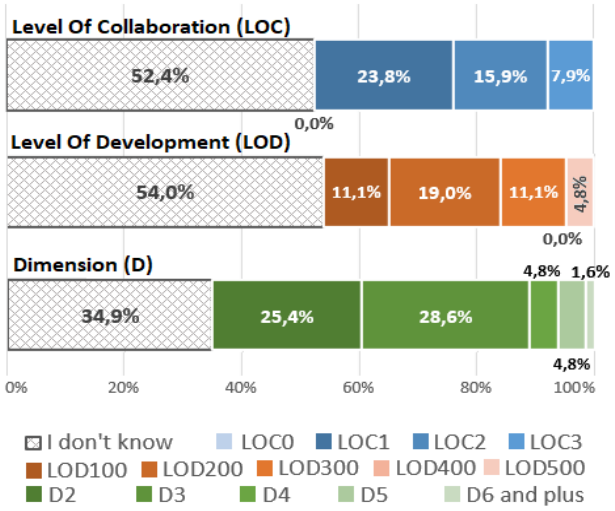

Fig. 9 Models BIM maturity level used in the Moroccan AEC industry.

1) Level Of Collaboration (LOC):

76.2% of Moroccan AEC stakeholders are still limited to LOC1 with no digital collaboration where, for a same project, each participant used his own tools and standards to develop independently his models, plans and details. Meanwhile, 15.9% used common standards for BIM tools (LOC3) enabling models of all collaborators to be combined. And 7.9% of the participants have used, in some of their projects, iBIM models where, for the same project, all contributors work on the same digital model through a collaborative platform (Fig. 9).

2) Level Of Development (LOD):

Only 4.8% of AEC operators have used LOD500 (as built) in some of their projects and none have used LOD400 (accurate form). Meanwhile, 11.1%, 19%, and 11.1% used LOD300 (Form), LOD200, and LOD100 respectively. Whereas 54% do not know the LOD parameter (Fig. 9).

3) Dimension:

It seems that this is the most known maturity parameter, yet only 35% do not know about it. Whereas the remaining 65% use mostly 2D and 3D models with 25.4% and 28.6% respectively. 4D (time) and 5D (cost) are used by 4.8% of AEC operators each. Meanwhile, only 1.8% of respondents use 6D (sustainability) or more (Fig. 9).

E. Level of Green BIM Adoption:

A tight percentage of Moroccan AEC stakeholders (1.6%) appeal to BIM software used for building ecological performance (Ecotec Analysis, Fig. 8) similarly only 1.6% include sustainable development in their models (6D or more, see Fig. 10), which call into question the general degree of consideration of energy and ecological performances in construction projects in Morocco.

This fact has been confirmed by the interviewed team of the "Quality and Technical affairs department" of the "Ministry of National Territory Use Planning, Town Planning, Housing and City Policy" responsible for the development of the AEC industry in Morocco. In fact, they confirmed that several actions have been undertaken by Morocco toward construction sustainably, particularly related to "energy efficiency", but without involving BIM technology.

F. Existing Measures urging BIM adoption in Morocco:

The scientometric literature review conducted by Saka and Chan [45] showed that no measures have been undertaken in African countries to encourage BIM adoption. Therefore, it was necessary to investigate the possible existing measures in Morocco.

For this purpose, the respondents have been asked to cite any related measures they are aware of and allot them into two categories: a- incentive measures and b- standards or law. As result, the survey bespoke that 87.3% of the AEC stakeholders do not reveal any measure. Indeed, 42.9% of them are sure that no measure exists in Morocco to urge BIM adoption against 12.7% that affirmed the opposite and highlighted the listed items in Table III:

TABLE III. LISTED INCENTIVES, LAWS, AND STANDARDS BY THE RESPONDENTS.

Laws / Standards	Rank Value
Law N° 25-90	Up to 70% support of training costs by OFPPT.
Law N° 66-12	Up to 70% support of software, equipment and
Law N° 12-90	related training costs by Maroc PME.

V. VALIDATION OF NEW FINDINGS:

Given the measures encouraging the adoption of BIM in Morocco, the feedback assessed three legal measures and two government incentives. To appraise their relevance and validate that they are related to BIM, complementary data have been collected using the official databases published by the specialized institutions and the feedback of an interviewed expert accredited by "GIAC-BTP" and "Maroc PME".

A. Legal-Related Measures:

1) Law N° 12-90 *[55]* 15 July 1992 "relating to town planning":

In this law, the legislator provides the legislative framework needed for realizing any project of Urban Development Master Plan in Morocco. For instance, technical aspects, neighborhoods' arrangement, conflict management between neighbors, assignment of sector designations and so on. It does not mention any particular action related to BIM adoption.

2) Law N° 25-90 *[56]* 15 July 1992 "relating to allotments, groups of dwellings and parcels":

This law sets the legislative framework of all aspects related to building allotment projects, groups of dwellings or parcels in Morocco. It does not mention any particular action related to BIM adoption.

3) Law N° 66-12 *[57]* 18 April 2019 "relating to the control and repression of offenses in town planning and construction":

It highlights the legislative disposals to be followed to control and oversee the realization of any town planning and construction project in Morocco. This law came to enhance the responsibilities range of architects, engineering firms, and contractors for the relevance and quality of realized work especially in case of workmanship and faults. It also brings amendments to laws 12-90, 25-90 and others. However, it does not mention any particular action related to BIM adoption but, according to the respondents, because of the heavy sanctions (financial penalties and imprisonment) imposed by this law, the AEC operators are more into moving from traditional practices to using BIM tools and avoid any default due to clashes.

B. Governmental incentives:

In Morocco, the companies wishing to benefit from public subsidies must call on firms or experts accredited by granting bodies, namely GIAC-BTP [58] and Maroc PME.

1) OFPPT Subsidies:

Office for vocational training and work promotion [59], the public organization in charge of promoting the vocational training by refunding them and in charge of technical trainings for young people to adapt their profiles to the actual needs of employment Market.

Inter-professional Council Assistance Group responsible for companies in AEC industry, GIAC-BTP, is the public organization responsible for approving the training programs proposed by the AEC companies.

The OFPPT could take charge of the payment of up to 70% of the total amount of training programs approved by the GIAC-BTP. According to the interviewed expert accredited by GIAC-BTP, BIM trainings are part of approved trainings listed by GIAC-BTP, and she has already helped many companies to benefit from this subvention to buy BIM trainings up to 70% of the total cost but limited to already-paid taxes by the company for trainings in the latest 3years. A fact that has been confirmed by the respondent representing OFPPT.

2) Maroc PME Subsidies:

The National Agency responsible for promoting small and medium enterprises, Maroc PME (Maroc – Petites et Moyennes Entreprises) is the operational organization representing the public authorities responsible for helping the Small and Medium Enterprises (SME) to develop their activities through trainings, setting development strategies and subventions.

In fact, Maroc PME [60] set a public incentive program to promote digital transformation for companies having annual cash flow between 10 and 200 million MAD. Maroc PME takes in charge the payment of the cost of the service up to 70% of the total amount of acquisition of an Information System (IS) in proprietary mode, including infrastructure and equipment, and 80% for IS in cloud mode (Table IV). According to the interviewed expert accredited by Maroc PME, Maroc PME allows this incentive, but only for companies operating in transforming industries and not those in the AEC fields.

TABLE IV. PUBLIC INCENTIVE'S PROGRAM TO PROMOTE DIGITAL TRANSFORMATION OF COMPANIES [60]

Action code	Support action	% of total investment	Cap (MAD)
Assistance for project management			
DIGIT02	Implement an IT solution		75000
DIGIT03	Strengthen the security of Information systems (ISs)	- 70% of the total cost of an IS in proprietary mode, including	100000
Access to cloud services			
DIGIT05	Access to cloud services	equipment and infrastructure	400000
Acquisition of IT solutions			
DIGIT04	Acquisition of IT solutions	- 80% if it is acquired in cloud mode	400000

VI. DISCUSSION:

BIM awareness rate in Morocco reaches 77%, which, according to the literature review, is one of the highest rates acknowledged in developing countries. Compared to other African countries, Morocco could be ranked in the fourth place after Egypt, Nigeria and, Kenya [45]. However, awareness does not necessarily mean a perfect understanding. In fact, 39% of Moroccan AEC operators either omit the collaboration condition required to consider a 3D model as a BIM model or conflate it with 3D modeling software. This point has been confirmed by the level of awareness of BIM tools where the most known BIM tools are software programs with a rate of 73%, headed by Revit,

whereas BIM hardware and collaboration platforms are barely known.

Fig. 1 Segmentation of Moroccan AEC stakeholders according to their BIM Awareness and Maximal used Maturity of BIM models

Morocco is already using the BIM technology to design and manage many projects such as the Big Theater of Rabat [61], Casa-Finance-City tower [62], and others. However, these projects are mainly large-scale and owned by either public, semi-public organizations, banks, or foreign investors. Generally, in terms of BIM adoption and use in Morocco, the study disclosed that:

- 44% of design/development stage operators (architects, engineering firms, and developers) have used BIM at least in one of their projects, against 38% of erection/construction stage operators (contractors and suppliers).
- 24% of the AEC stakeholders use BIM in some of their projects and 8% even use iBIM where BIM models could commonly be developed through collaborative platforms on the cloud (Figure 10).
- At least 19% of the AEC stakeholders use BIM in more than one-quarter of their projects, where 7% use it in more than 50% of their projects,
- 44% of the AEC stakeholders have already planned and designed a strategy for BIM adoption, 38% are progressively implementing it and 6% have already set it. In fact, all the strategies focus on three main points: 1) staff training, 2) software acquisition and 3) hardware acquisition but some stakeholders have also included "Creation of customers' need for BIM" in their strategies.
- 1.6% of the AEC operators appeal to BIM software used for building ecological performance. Similarly, only 1.8% include sustainable development in their models (6D or more, Figure 10), which calls into question the general degree of consideration of energy and ecological performances in the building sector.

In the same context, the study demonstrated that more than half of AEC Moroccan stakeholders are not familiar with the main parameters of BIM maturity, namely LOC and LOD. In fact, the surveys disclosed that at least 76% of Moroccan AEC operators still use traditional practices and/or non-collaborative models instead of BIM models (Figure 10) where 16% who use 3D models (Figure 10) omitted that utilizing level 2 as LOC is the key condition to consider any 3D model as a BIM model. Meantime, whereas 59% of Moroccan AEC operators do not use BIM in their projects, 62% of them have never used BIM tools. This difference confirms once more the lack of a decent BIM understanding.

Furthermore, the study revealed that no measure toward BIM adoption has been undertaken yet by Moroccan public bodies. However, the imposing sanctions dictated by some laws related to design, erection, and management of the AEC projects could be a real driver for Moroccan AEC stakeholders to adopt BIM in order to reduce defaults' probabilities leading to be heavily charged. Likewise, the companies willing to adopt BIM could benefit from the already-set incentives namely the general program, set by OFPPT, to refund up to 70% of training costs.

VII. CONCLUSION

In absence of any research discussing BIM awareness and/or implementation in Morocco, this study was conducted to fill this gap. It addresses the state-of-the-art of BIM in this country based on a rigorous literature review, analysis of the Moroccan AEC context, web-based and interview-based surveys that were conducted among 97 of reputed and large-scale AEC operators in Morocco.

The study revealed that the BIM awareness rate in Morocco reaches approximately 77% among the surveyed AEC firms but 49% have a faultless understanding of the BIM concept. Meanwhile, in terms of BIM tools awareness, BIM software represents the most known BIM tools with Revit on the top. Whereas BIM hardware and collaboration platforms are barely known. Despite that several large-scale projects are using BIM as the main working tool in Morocco, the BIM adoption rate is still modest where only 24% of AEC operators use BIM or iBIM models, 41% have already used it at least once, and 44% of them have already started BIM adoption strategies.

On the other hand, the Moroccan policymakers have not undertaken any measure yet to encourage BIM adoption in terms of either incentives or regulation, but the heavy sanctions imposed by some laws organizing design and erection phases seem to be one of the real drivers toward BIM adoption.

Despite that this study has discussed in detail the awareness and implementation aspects of BIM in Morocco, it is still limited and could be developed to explore the challenges facing the Moroccan AEC operators toward a factual BIM implementation. Furthermore, the survey considered a sample of large-scale companies. However, the Moroccan AEC industry accounts for a considerable percentage of small and very small companies, which might be considered as an additional limitation or an opportunity for further studies.

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